BS EN 13835:2012

BSI Standards Publication

Founding — Austenitic cast irons

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National foreword

This British Standard is the UK implementation of EN 13835:2012. It supersedes BS EN 13835:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/111, Steel Castings and Forgings.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN 13835:2012) has been prepared by Technical Committee CEN/TC 190 "Foundry technology", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2012, and conflicting national standards shall be withdrawn at the latest by July 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights other than those identified above. CEN [and/or] CENELEC shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13835:2002.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 8 "High alloyed cast iron" to revise EN 13835:2002.

Annex H provides details of significant technical changes between this European Standard and the previous edition.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard classifies a range of cast irons principally used for their heat and corrosion resistance properties. These properties are obtainable from the engineering grades in this European Standard. The special purpose grades also exhibit heat and corrosion resistance properties, but are used principally for their magnetic properties, or very low expansion characteristics.

The austenitic cast irons are a range of high-alloyed materials with an austenitic matrix, containing nickel, manganese and sometimes copper and chromium. Carbon is present either as graphite flakes or as spheroids. The spheroidal graphite grades have superior mechanical properties.

The properties of the austenitic cast irons depend upon them having the appropriate structure and mechanical properties for the application. These properties are dependent upon the control of metal composition within the specified grades and the metal processing route.

Typical applications for the various grades are given in Annex A.

In this European Standard a new designation system by number, as established in EN 1560 [3], is given.

NOTE This designation system by number is based on the structure and rules of EN 10027-2 [4] and so corresponds with the European numbering system for steel and other materials.

Some austenitic cast iron grades can be used for pressure equipment.

The permitted material grades of austenitic cast iron for pressure applications and the conditions for their use are given in specific product or application standards.

For the design of pressure equipment, specific design rules apply.

Annex ZA gives information relating to the conformance of permitted austenitic cast iron grades to the Pressure Equipment Directive 97/23/EC.

1 Scope

This European Standard specifies the grades and corresponding requirements for austenitic cast irons. These requirements are specified in terms of:

— graphite form and metal structure: either flake or spheroidal graphite in an austenitic matrix;

— chemical composition: as given for each of the grades;

— mechanical properties measured on machined test pieces prepared from cast samples.

This standard does not cover technical delivery conditions for iron castings, see EN 1559-1 [1] and EN 1559-3 [2].

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 764-5:2002, *Pressure equipment — Part 5: Compliance and inspection — Documentation of materials*

EN 10204:2004, *Metallic products — Types of inspection documents*

EN ISO 148-1:2010, *Metallic materials — Charpy impact test — Part 1: Test method (ISO 148-1:2009)*

EN ISO 945-1, *Microstructure of cast irons —Part 1: Graphite classification by visual analysis (ISO 945-1)*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1)*

EN ISO 6892-1:2009, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2009)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
austenitic cast iron
cast material with an austenitic matrix which is iron, carbon and silicon based and alloyed with nickel, manganese, copper and/or chromium in order to stabilize the austenitic structure at room temperature; the graphite can be present in flake or spheroidal form

3.2
cast sample
quantity of material cast to represent the cast material, including separately cast sample, side by side cast sample and cast-on sample

3.3
separately cast sample
sample cast in a separate sand mould under representative manufacturing conditions and material grade

3.4
side-by-side cast sample
sample cast in the mould alongside the casting, with a joint running system

3.5
cast-on sample
sample attached directly to the casting

3.6
relevant wall thickness
wall thickness representative of the casting defined for the determination of the size of the cast samples to which the mechanical properties apply

4 Designation

The material shall be designated either by symbol or by number as given in Tables 1 to 4.

NOTE The comparison of EN 13835 grade designations with the grades from ISO 2892:2007 [5] is given in Annex B.

5 Order information

The following information shall be supplied by the purchaser:

a) number of this European Standard;

b) designation of the material;

c) relevant wall thickness;

d) any special requirements.

All requirements shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order (e.g. technical delivery conditions according to EN 1559-1 and EN 1559-3).

6 Manufacture

Unless otherwise specified by the purchaser, the method of manufacture of austenitic cast irons shall be left to the discretion of the manufacturer.

The manufacturer shall ensure that the requirements defined in this European Standard are met for the material grade specified in the order.

All agreements between the manufacturer and the purchaser shall be made by the time of acceptance of the order.

NOTE For certain applications heat treatment of austenitic cast irons is beneficial, but should only be specified where service conditions demand such treatment. The heat treatment processes employed are stress relieving and high temperature stabilising treatments. Details of these treatments are given in Annex C.

7 Requirements

7.1 Chemical composition

The chemical composition of austenitic cast iron grades shall be in accordance with Table 1 for the engineering grades and Table 2 for the special purpose grades. Spheroidal graphite grades are produced either by magnesium treatment or by treatment with another suitable nodulariser. Unless otherwise specified, other elements may be present at the discretion of the manufacturer provided that they do not alter the structure or adversely affect the properties. If the presence of any element specified in Tables 1 or 2 is required to be outside the limits indicated, or if any other elements are required, their contents shall be agreed between the manufacturer and the purchaser and specified in the order.

For information about the effect of alloying elements see Annex D.

7.2 Mechanical properties

7.2.1 General

The property values given in Tables 3 and 4 apply to austenitic cast iron cast in sand moulds or moulds of comparable thermal behaviour. Subject to amendments to be agreed upon in the order, they can apply to castings obtained by alternative methods.

Requirements regarding mechanical testing are described in 9.2 and 9.3.

NOTE Tensile testing requires sound test pieces in order to guarantee pure uni-axial stress during the test.

Additional information on mechanical and physical properties is given in Annex E.

7.2.2 Test pieces machined from cast samples

The mechanical properties of the grades of austenitic cast irons obtained from cast samples with a thickness or a diameter equal to or smaller than 25 mm shall be in accordance with:

— Table 3 for austenitic spheroidal graphite cast iron grades, with specified minimum impact energy;

— Table 4 for austenitic grey iron grades and austenitic spheroidal graphite cast iron grades, without specified minimum impact energy.

The impact energy values given in Table 3 at room temperature, if applicable, shall only be determined if specified by the purchaser by the time of acceptance of the order.

Other requirements, such as the mechanical properties to be met on samples with a thickness more than 25 mm shall be agreed between the manufacturer and the purchaser and specified in the order.

7.2.3 Test pieces machined from samples cut from a casting

If applicable, the manufacturer and the purchaser shall agree on:

— location(s) on a casting where the sample(s) shall be taken;

— mechanical properties that shall be measured;

— minimum values, or allowable range of values, for these mechanical properties.

NOTE 1 The properties and the structure of castings are not uniform, depending on the complexity of the castings and variation in their section thickness.

NOTE 2 Mechanical properties for test pieces cut from a casting are affected not only by material properties (subject of this European Standard) but also by the local casting soundness (not subject of this European Standard).

7.2.4 Hardness

Brinell hardness and its range values for the grades listed in Tables 1 and 2 shall only be specified when agreed between the manufacturer and the purchaser by the time of acceptance of the order.

Information regarding Brinell hardness is given in Annex E.

Table 1 — Chemical composition of austenitic cast irons — Engineering grades

Graphite form	Material designation		Chemical composition in % (mass fraction)						
	Symbol	Number	C	Si	Mn	Ni	Cr	P	Cu
Flake	EN-GJLA-XNiCuCr15-6-2	5.1500	max. 3,0	1,0 to 2,8	0,5 to 1,5	13,5 to 17,5	1,0 to 3,5	max. 0,25	5,5 to 7,5
Spheroidal	EN-GJSA-XNiCr20-2	5.3500	max. 3,0	1,5 to 3,0	0,5 to 1,5	18,0 to 22,0	1,0 to 3,5	max. 0,08	max. 0,50
	EN-GJSA-XNiMn23-4	5.3501	max. 2,6	1,5 to 2,5	4,0 to 4,5	22,0 to 24,0	max. 0,2	max. 0,08	max. 0,50
	EN-GJSA-XNiCrNb20-2 [a]	5.3502 [a]	max. 3,0	1,5 to 2,4	0,5 to 1,5	18,0 to 22,0	1,0 to 3,5	max. 0,08	max. 0,50
	EN-GJSA-XNi22	5.3503	max. 3,0	1,0 to 3,0	1,5 to 2,5	21,0 to 24,0	max. 0,5	max. 0,08	max. 0,50
	EN-GJSA-XNi35	5.3504	max. 2,4	1,5 to 3,0	0,5 to 1,5	34,0 to 36,0	max. 0,2	max. 0,08	max. 0,50
	EN-GJSA-XNiSiCr35-5-2	5.3505	max. 2,0	4,0 to 6,0	0,5 to 1,5	34,0 to 36,0	1,5 to 2,5	max. 0,08	max. 0,50

[a] Good weldability of this material with: % Nb ≤ [0,353 − 0,032 (% Si + 64 × % Mg)]. The normal range of Nb is 0,12 % to 0,20 %.

Table 2 — Chemical composition of austenitic cast irons — Special purpose grades

Graphite form	Material designation		Chemical composition in % (mass fraction)						
	Symbol	Number	C	Si	Mn	Ni	Cr	P	Cu
Flake	EN-GJLA-XNiMn13-7	5.1501	max. 3,0	1,5 to 3,0	6,0 to 7,0	12,0 to 14,0	max. 0,2	max. 0,25	max. 0,5
Spheroidal	EN-GJSA-XNiMn13-7	5.3506	max. 3,0	2,0 to 3,0	6,0 to 7,0	12,0 to 14,0	max. 0,2	max. 0,08	max. 0,5
	EN-GJSA-XNiCr30-3	5.3507	max. 2,6	1,5 to 3,0	0,5 to 1,5	28,0 to 32,0	2,5 to 3,5	max. 0,08	max. 0,5
	EN-GJSA-XNiSiCr30-5-5	5.3508	max. 2,6	5,0 to 6,0	0,5 to 1,5	28,0 to 32,0	4,5 to 5,5	max. 0,08	max. 0,5
	EN-GJSA-XNiCr35-3	5.3509	max. 2,4	1,5 to 3,0	0,5 to 1,5	34,0 to 36,0	2,0 to 3,0	max. 0,08	max. 0,5

Table 3 — Mechanical properties measured at (23 ± 5) °C on test pieces machined from cast samples of austenitic spheroidal graphite cast irons — Grades with specified minimum impact energy

Graphite form	Material designation		0,2 % proof strength $R_{p0,2}$ MPa min.	Tensile strength R_m MPa min.	Elongation A % min.	Mean value of impact energy of 3 tests V-notch Charpy J min.
	Symbol	Number				
Spheroidal	EN-GJSA-XNiCr20-2	5.3500	210	370	7	13 [a]
	EN-GJSA-XNiMn23-4	5.3501	210	440	25	24
	EN-GJSA-XNiCrNb20-2	5.3502	210	370	7	13 [a]
	EN-GJSA-XNi22	5.3503	170	370	20	20
	EN-GJSA-XNi35	5.3504	210	370	20	13 [a]
	EN-GJSA-XNiSiCr35-5-2	5.3505	200	370	10	7 [a]
	EN-GJSA-XNiMn13-7	5.3506	210	390	15	16

[a] Optional requirement by agreement between the manufaturer and the purchaser.

Table 4 — Mechanical properties at (23 ± 5) °C measured on test pieces machined from cast samples of austenitic cast irons — Grey iron grades and spheroidal graphite cast iron grades without specified minimum impact energy

Graphite form	Material designation		0,2 % proof strength $R_{p0,2}$ MPa min.	Tensile strength R_m MPa min.	Elongation A % min.
	Symbol	Number			
Flake	EN-GJLA-XNiMn13-7	5.1501	—	140	—
	EN-GJLA-XNiCuCr15-6-2	5.1500	—	170	—
Spheroidal	EN-GJSA-XNiCr30-3	5.3507	210	370	7
	EN-GJSA-XNiSiCr30-5-5	5.3508	240	390	—
	EN-GJSA-XNiCr35-3	5.3509	210	370	7

7.3 Microstructure

Microstructure shall only be specified when agreed between the manufacturer and purchaser, by the time of acceptance of the order. When a microstructure examination is agreed, the location for sampling, the methods used to examine the microstructure, and acceptance criteria shall be subject to that agreement. If the graphite structure is agreed upon, it shall be specified in accordance with EN ISO 945-1. The microstructure examination shall be performed in accordance with 9.5.

8 Sampling

8.1 General

Samples shall be made from the same material as that used to produce the casting(s) which they represent.

Several types of samples (separately cast samples, side-by-side cast samples, cast-on samples, samples cut from a casting) can be used, depending on the mass and wall thickness of the casting.

When relevant, the type of sample should be agreed between the manufacturer and the purchaser. Unless otherwise agreed, the choice of option is left to the discretion of the manufacturer.

When the mass of the casting exceeds 2 000 kg and its thickness exceeds 100 mm, cast-on samples should preferably be used; the dimensions and the location of the cast-on sample shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order.

If the spheroidisation treatment is carried out in the mould (in-mould process), the separately cast sample should be avoided.

All samples shall be adequately marked to guarantee full traceability to the castings which they represent.

The samples shall be subject to the same heat treatment, as that of the castings they represent, if any.

The samples for chemical analysis shall be cast in a manner which ensures that the accurate chemical composition can be determined.

8.2 Cast samples

8.2.1 Size of cast samples

The size of the sample shall be in correspondence with the relevant wall thickness of the casting as shown in Table 5.

If other sizes are used, this shall be agreed between the manufacturer and purchaser.

Table 5 — Types and sizes of cast samples and size of tensile test pieces in relation to relevant wall thickness of the casting

Relevant wall thickness t mm	Type of sample				Preferred diameter of tensile test piece [a] d mm
	Option 1 U-shaped	Option 2 Y-shaped	Option 3 Round bar	Cast-on sample	
	(See Figure 1)	(See Figure 2)	(See Figure 3)	(See Figure 4)	
$t \leq 12,5$	—	I	Types b, c	A	7 (Option 3: 14 mm)
$12,5 < t \leq 30$	—	II	Types a, b, c	B	14
$30 < t \leq 60$	x [b]	III	—	C	14
$60 < t \leq 200$	—	IV	—	D	14

[a] Other diameters, in accordance with Figure 5, may be agreed between the manufacturer and the purchaser.

[b] The cooling rate of this cast sample corresponds to that of a 40 mm thick wall.

8.2.2 Frequency and number of tests

Samples, representative of the material, shall be produced at a frequency in accordance with the process quality assurance procedure adopted by the manufacturer or as agreed with the purchaser.

In the absence of either a process quality assurance procedure or any agreement between the manufacturer and the purchaser, a minimum of one cast sample for the tensile test shall be produced to confirm the material at a frequency to be agreed between the manufacturer and the purchaser by the time of acceptance of the order.

When impact tests are agreed by the time of acceptance of the order, samples shall be produced at a frequency to be agreed between the manufacturer and the purchaser.

8.2.3 Separately cast samples

The samples shall be cast separately in sand moulds under representative manufacturing conditions.

The moulds used to cast the separately cast samples shall have comparable thermal behaviour to the moulding material used to cast the castings.

The samples shall meet the requirements of either Figures 1, 2 or 3.

The samples shall be removed from the mould at a temperature similar to that of the castings.

8.2.4 Side-by-side cast samples

Side-by-side cast samples are representative of the castings concurrently cast and also of all other castings of a similar relevant wall thickness from the same test unit.

When mechanical properties are required for a series of castings belonging to the same test unit, the side-by-side cast sample(s) shall be produced in the last mould(s) poured.

The samples shall meet the requirements of either Figures 1, 2 or 3.

8.2.5 Cast-on samples

Cast-on samples are representative of the castings to which they are attached and also of all other castings of a similar relevant wall thickness from the same test unit.

When mechanical properties are required for a series of castings belonging to the same test unit, the cast-on sample(s) shall be produced in the last mould(s) poured.

The sample shall have a general shape as indicated in Figure 4 and the dimensions shown therein.

The location of the cast-on sample shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order, taking into account the shape of the casting and the running system, in order to avoid any unfavourable effect on the properties of the adjacent material.

8.2.6 Test pieces machined from cast samples

The tensile test piece shown in Figure 5 and, if applicable, the impact test piece shown in Figure 6 shall be machined from a sample shown in Figure 3 or from the hatched part of Figures 1, 2 and 4.

The sectioning procedure for cast samples shall be in accordance with Annex F.

Unless otherwise agreed, the preferred diameter for the test piece shall be used.

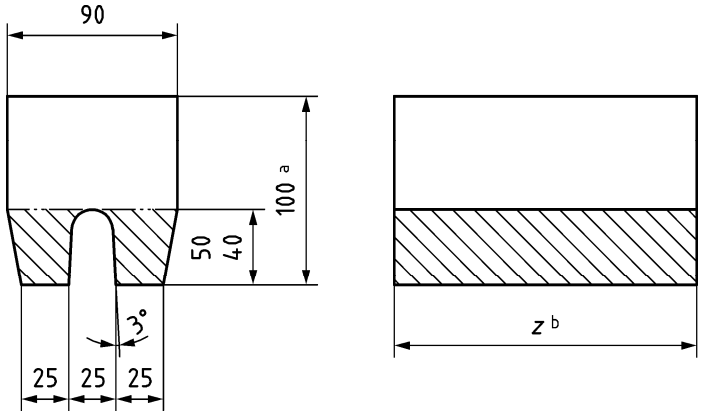
8.3 Samples cut from a casting

In addition to the requirements of the material, the manufacturer and the purchaser may agree on the properties required at stated locations in the casting. These properties shall be determined by testing test pieces machined from samples cut from the casting at these stated locations.

The manufacturer and the purchaser shall agree on the dimensions of these test pieces.

In the absence of any directions by the purchaser, the manufacturer may choose the locations from which to cut the samples and the dimensions of the test pieces.

Dimensions in millimetres



Key

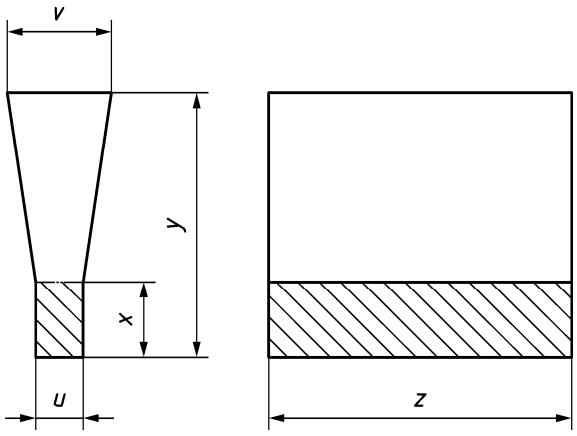
a for information only

b the length z shall be chosen to allow a test piece of dimensions shown in Figure 5 to be machined from the sample

The thickness of the sand mould surrounding the samples shall be at least 40 mm.

Figure 1 — Separately or side-by-side cast sample — Option 1: U-shaped sample

Dimensions in millimetres



Dimension	Type			
	I	II	III	IV
u	12,5	25	50	75
v	40	55	100	125
x	25	40	50	65
y [a]	135	140	150	175
z [b]	A function of the test piece length			

[a] For information only.

[b] z shall be chosen to allow a test piece of dimensions shown in Figure 5 to be machined from the sample.

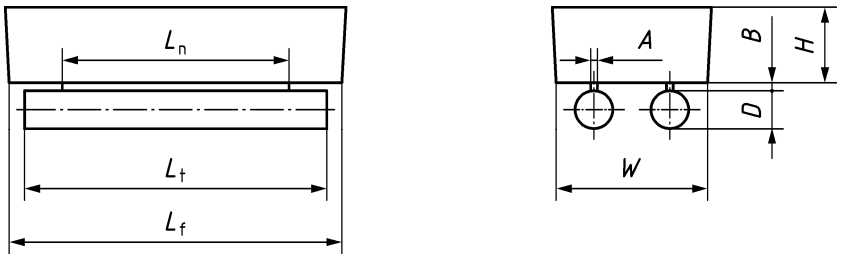
The thickness of the sand mould surrounding the samples shall be at least:

— 40 mm for types I and II;

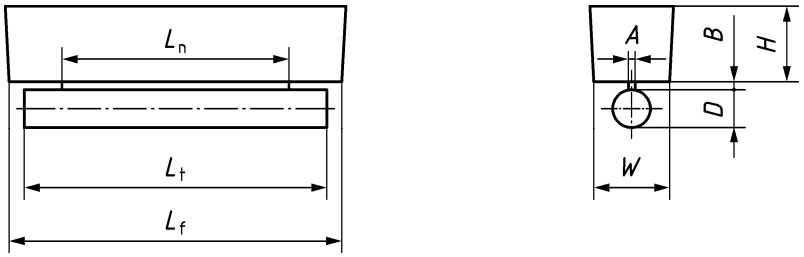
— 80 mm for type III and IV.

Figure 2 — Separately cast or side by side cast samples — Option 2: Y-shaped sample

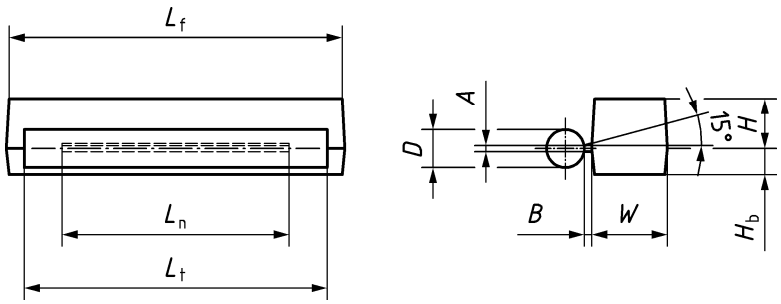
Dimensions in millimetres



Type a



Type b



Type c

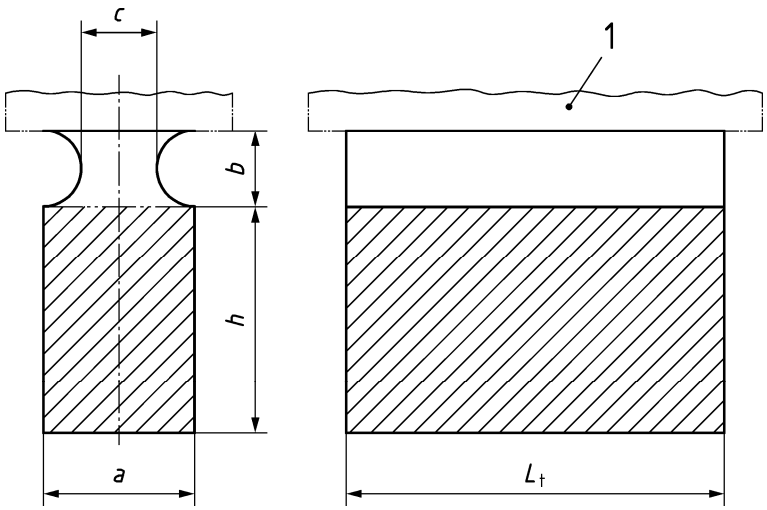
Type	*A*	*B*	*D*	*H*	H_b	L_f	L_n	L_t	*W*
a	4,5	5,5	25	50	—	L_t + 20	L_t – 50	a	100
b	4,5	5,5	25	50	—	L_t + 20	L_t – 50		50
c	4,0	5,0	25	35	15	L_t + 20	L_t – 50		50

a L_t shall be chosen to allow a test piece of dimensions shown in Figure 5 to be machined from the sample.

The thickness of the sand mould surrounding the samples shall be at least 40 mm.

Figure 3 — Separately cast or side by side cast samples — Option 3: Round bar-shaped sample

Dimension in millimetres



Type	Relevant wall thickness of castings t	a	b max.	c min.	h	L_t
A	$t \leq 12,5$	15	11	7,5	20 to 30	a
B	$12,5 < t \leq 30$	25	19	12,5	30 to 40	
C	$30 < t \leq 60$	40	30	20	40 to 65	
D	$60 < t \leq 200$	70	52,5	35	65 to 105	

a L_t shall be chosen to allow a test piece of a dimension shown in Figure 5 to be machined from the sample.

The thickness of the sand mould surrounding the samples shall be at least:

— 40 mm for types A and B;

— 80 mm for types C and D.

If smaller dimensions are agreed, the followings relationships apply:

$b = 0,75 \times a$

$c = 0,5 \times a$

The location of cast-on samples shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order, taking into account the shape of the casting and the running system, in order to avoid any unfavourable effect on the properties of the adjacent material.

Figure 4 — Cast-on samples

9 Testing

9.1 Chemical analysis

The methods used to determine the chemical composition of the material shall be in accordance with validated procedures. Any requirement for traceability shall be agreed between the manufacturer and the

purchaser at the time of the acceptance of the order. The chemical analysis shall be carried out on a test sample made from the same melt as the castings the sample represents.

NOTE Optical emission spectrometry and X-ray fluorescence techniques are acceptable methods of analysis.

9.2 Tensile test

The tensile test shall be carried out in accordance with EN ISO 6892-1:2009.

The preferred test piece diameter is 14 mm but, either for technical reasons or for test pieces machined from samples cut from the casting, it is permitted to use a test piece of different diameter (see Figure 5). For either of these exceptions the original gauge length of the test piece shall conform to the equation:

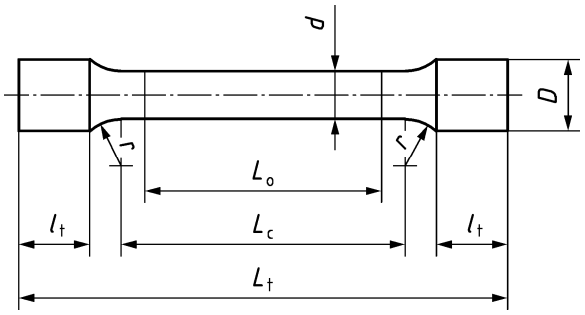
$$L_o = 5{,}65 \times \sqrt{S_o} = 5 \times d$$

where

L_o is the original gauge length;

S_o is the original cross-sectional area of the test piece.

Dimensions in millimetres



d	L_o	L_c min.
5	25	30
7	35	42
10	50	60
14 [a]	70	84
20	100	120
[a] Preferred dimension for 25 mm cast sample diameter.		

where

L_o is the original gauge length; here $L_o = 5 \times d$;

d is the original diameter of the test piece;

L_c is the parallel length; $L_c > L_o$ (in principle $L_c - L_o \geq d$);

L_t is the total length of the test piece according to L_c and l_t;

r is the transition radius, which shall be at least 4 mm.

NOTE The method of gripping the ends of the test pieces, together with the length l_t, can be agreed between the manufacturer and the purchaser.

Figure 5 — Tensile test piece

9.3 Impact test

The impact test shall be carried out on three Charpy V-notched impact test pieces (see Figure 6) in accordance with EN ISO 148-1:2010 using test equipment with an appropriate energy to determine the properties correctly.

Dimensions in millimetres

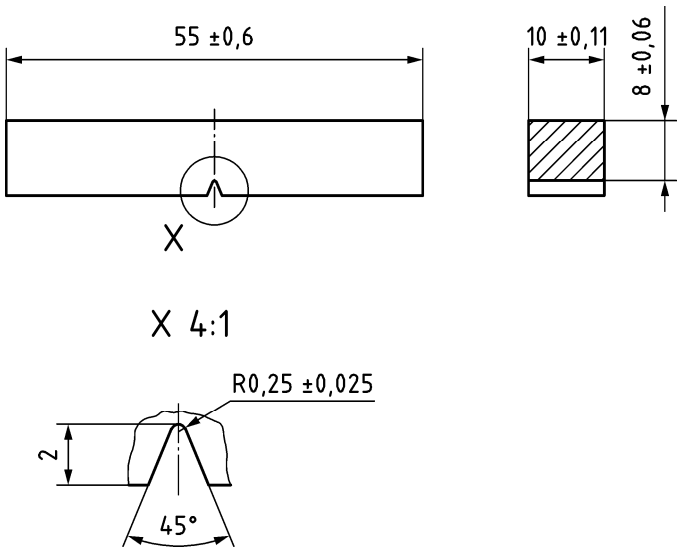


Figure 6 — Charpy V-notched impact test piece

9.4 Hardness test

The hardness shall be determined as Brinell hardness in accordance with EN ISO 6506-1.

Alternative hardness tests and the corresponding required hardness values may also be agreed.

The test shall be carried out on the test piece or at one or several points on the casting after preparation of the testing area in accordance with the agreement between the manufacturer and the purchaser.

If the measurement locations are not the subject of an agreement, they shall be chosen by the manufacturer.

If it is not possible to carry out the hardness test on the casting, then by agreement between the manufacturer and the purchaser, the hardness test may be carried out on a knob cast-on to the casting.

9.5 Microstructure examination

Microstructure examination shall be performed on a sample cut from a casting, or from a cast sample. The sample shall have comparable solidification and cooling conditions as the relevant section of the casting.

Non-destructive methods can also give information regarding the graphite or matrix structure.

In case of a dispute, the results of the microscopic examination shall prevail.

9.6 Physical properties

Annex G gives information regarding the sample preparation for the determination of physical properties.

10 Retests

10.1 Need for retests

Retests shall be carried out if a test is not valid.

Retests are permitted to be carried out if a test result does not meet the specified requirements for the specified grade.

10.2 Test validity

A test is not valid if there is:

a) a faulty mounting of the test piece or defective operation of the test machine;

b) a defective test piece because of incorrect pouring or incorrect machining;

c) a fracture of the tensile test piece outside the gauge length;

d) a casting defect in the test piece, evident after fracture.

In the above cases, a new test piece shall be taken from the same cast sample or from a duplicate sample cast at the same time to replace those invalid test results.

10.3 Nonconforming test results

If any test gives results which do not conform to the specified requirements, for reasons other than those given in 10.2, the manufacturer shall have the option to conduct retests.

If the manufacturer conducts retests, two retests shall be carried out for each failed test.

If both retests give results that meet the specified requirements, the material shall be deemed to conform to this European Standard.

If one or both retests give results that fail to meet the specified requirements, the material shall be deemed not to conform to this European Standard.

10.4 Heat treatment of samples and castings

Unless otherwise specified, in the case of castings in the as-cast condition with mechanical properties not in conformance with this European Standard, a heat treatment may be carried out.

In the case of castings which have undergone a heat treatment and for which the test results are not valid or not satisfactory, the manufacturer shall be permitted to re-heat treat the castings and the representative samples. In this event, the samples shall receive the same number of heat treatments as the castings.

If the results of the tests carried out on the re-heat treated samples are satisfactory, then the re-heat treated castings shall be regarded as conforming to the specified requirements of this European Standard.

The number of re-heat treatment cycles shall not exceed two.

11 Inspection documentation

When requested by the purchaser and agreed with the manufacturer, the manufacturer shall issue for the products the appropriate inspection documentation according to EN 10204:2004.

When ordering material for pressure equipment applications, the equipment manufacturer has the obligation to request appropriate inspection documentation according to the applicable product or application standard(s), EN 764-5:2002 and EN 10204:2004.

The material manufacturer is responsible for affirming conformity with the specification for the material ordered.

Annex A
(informative)

Properties and applications of the austenitic cast iron grades

Table A.1 — Properties and applications of the austenitic cast iron grades

Material designation		Properties	Applications
Symbol	Number		
Engineering grades			
EN-GJLA-XNiCuCr15-6-2	5.1500	Good corrosion resistance, particularly to alkalis, dilute acids, sea water and salt solutions; improved heat resistance, good bearing properties, high expansion coefficient, non-magnetisable with low chromium content.	Pumps, valves, furnace components, bushings, piston rings for light metal alloy pistons, non-magnetisable castings.
EN-GJSA-XNiCr20-2	5.3500	Good corrosion and heat resistance. Good bearing properties, high coefficient of thermal expansion. Non-magnetisable with low chromium content. Increased high temperature resistance if 1 % Mo (mass fraction) is added.	Pumps, valves, compressors, bushings, turbocharger housings, exhaust gas manifolds, non-magnetisable castings.
EN-GJSA-XNiMn23-4	5.3501	Particularly high ductility. Remains tough down to – 196 °C. Non-magnetisable.	Castings for refrigeration engineering for use down to – 196 °C.
EN-GJSA-XNiCrNb20-2	5.3502	Suitable for production welding, the other properties being as for EN-GJSA-XNiCr20-2 (5.3500).	As for EN-GJSA-XNiCr20-2 (5.3500).
EN-GJSA-XNi22	5.3503	High ductility. Lower corrosion and heat resistance than EN-GJSA-XNiCr20-2 (5.3500). High expansion coefficient. Remains tough down to – 100 °C. Non-magnetisable.	Pumps, valves, compressors, bushings, turbocharger housings. Exhaust gas manifolds, non-magnetisable castings.
EN-GJSA-XNi35	5.3504	Lowest thermal expansion of all cast irons. Resistant to thermal shock.	Parts with dimensional stability for machine tools, scientific instruments. Moulds for glass.
EN-GJSA-XNiSiCr35-5-2	5.3505	Specially heat resistant. Higher ductility and higher creep strength than EN-GJSA-XNiCr35-3 (5.3509).	Gas turbine housing parts, exhaust gas manifolds, turbocharger housings.
Special purpose grades			
EN-GJLA-XNiMn13-7	5.1501	Non-magnetisable.	Non-magnetisable castings, e.g. pressure covers for turbine generator sets, housings for switchgear, insulator flanges, terminals, ducts.
EN-GJSA-XNiMn13-7	5.3506	Non-magnetisable, similar to EN-GJLA-XNiMn13-7 (5.1501) but with improved mechanical properties.	Non-magnetisable castings, e.g. covers for turbine generator sets, housings for switchgear, insulator flanges, terminals, ducts.
EN-GJSA-XNiCr30-3	5.3507	Mechanical properties similar to EN-GJSA-XNiCrNb20-2 (5.3502), but better corrosion and heat resistance, intermediate expansion coefficient, particularly resistant to thermal shock and good high temperature resistance when 1 % Mo (mass fraction) is added.	Pumps, boilers, valves, filter parts, exhaust gas manifolds, turbocharger housings.
EN-GJSA-XNiSiCr30-5-5	5.3508	Particularly high corrosion, erosion and heat resistance. Intermediate expansion coefficient.	Pumps, fittings, exhaust gas manifolds, turbocharger housings, castings for industrial furnaces.
EN-GJSA-XNiCr35-3	5.3509	Similar to EN-GJSA-XNi35 (5.3504) but with improved high temperature resistance particularly when 1 % Mo (mass fraction) is added.	Gas turbine housing parts. Moulds for glass.

Annex B
(informative)

Comparison of austenitic cast iron material designations according to EN 1560 and ISO/TR 15931 [3], [6]

This informative annex compares the material designation of the standardized grades of austenitic cast iron based on the ISO and EN designation systems.

Table B.1 — Material designations of austenitic cast irons

EN 13835:2011		EN 13835:2002	ISO 2892
Symbol	**Number**	**Number**	**Material designation**
EN-GJLA-XNiCuCr15-6-2	5.1500	EN-JL3011	ISO 2892/JLA/XNiCuCr15-6-2
EN-GJLA-XNiMn13-7	5.1501	EN-JL3021	ISO 2892/JLA/XNiMn13-7
EN-GJSA-XNiCr20-2	5.3500	EN-JS3011	ISO 2892/JSA/XNiCr20-2
EN-GJSA-XNiMn23-4	5.3501	EN-JS3021	ISO 2892/JSA/XNiMn23-4
EN-GJSA-XNiCrNb20-2	5.3502	EN-JS3031	ISO 2892/JSA/XNiCrNb20-2
EN-GJSA-XNi22	5.3503	EN-JS3041	ISO 2892/JSA/XNi22
EN-GJSA-XNi35	5.3504	EN-JS3051	ISO 2892/JSA/XNi35
EN-GJSA-XNiSiCr35-5-2	5.3505	EN-JS3061	ISO 2892/JSA/XNiSiCr35-5-2
EN-GJSA-XNiMn13-7	5.3506	EN-JS3071	ISO 2892/JSA/XNiMn13-7
EN-GJSA-XNiCr30-3	5.3507	EN-JS3081	ISO 2892/JSA/XNiCr30-3
EN-GJSA-XNiSiCr30-5-5	5.3508	EN-JS3091	ISO 2892/JSA/XNiSiCr30-5-5
EN-GJSA-XNiCr35-3	5.3509	EN-JS3101	ISO 2892/JSA/XNiCr35-3

Annex C
(informative)

Heat treatment

C.1 Stress relief

C.1.1 Stress relief can be applied to all grades of austenitic cast iron, but is particularly recommended under the following conditions:

a) when the casting is of such complexity that excessive residual casting stresses can be expected which could lead to dimensional changes during machining or in service;

b) when complex castings are intended for operation under conditions when stress corrosion cracking might otherwise occur: for example when handling warm saline or highly alkaline solutions.

It can be advantageous to carry out stress relieving after rough machining.

C.1.2 The recommended stress relief heat treatment is as follows:

a) heat up to between 625 °C and 650 °C at a rate not exceeding 150 °C/h;

b) hold within this temperature range for 2 h plus 1 h per 25 mm section thickness;

c) cool down to 200 °C in the furnace at a rate not exceeding 100 °C/h;

d) air cool.

C.2 Heat treatment for high temperature stability

Where austenitic iron castings are used for static or cyclic elevated temperature service at 500 °C or above, and where it is essential that close dimensional tolerances are held, a high temperature structural stabilising heat treatment can be given.

The recommended high temperature structural stabilising heat treatment is as follows:

a) heat up to between 875 °C and 900 °C at a rate not exceeding 150 °C/h;

b) hold within this temperature range for 2 h plus 1 h per 25 mm section thickness;

c) cool down to 500 °C in the furnace at a rate not exceeding 50 °C/h;

d) air cool.

For certain critical components, this treatment can be followed by a stress relief treatment after rough machining. It should be noted that the austenitic cast iron grade EN-GJLA-XNiCuCr15-6-2 (5.1500) which contains copper should not be given a high temperature structural stabilising heat treatment.

Annex D
(informative)

Effect of alloying elements

The austenitic matrix is obtained by the addition of nickel, manganese and copper. Increasing chromium additions raise strength, hardness and resistance to scale formation, improve weldability and reduces linear expansion. In the case of the lower alloy grades it is important not to be below the lower limits for the nickel content because otherwise the matrix will no longer be solely austenitic. Too low a content of nickel, manganese or copper will result in the occurrence of ferromagnetism, increased hardness and impair machinability. For thick-walled castings, because of the slow cooling rate, the percentage of austenite stabilising elements should not be at the lower limit.

Machinability improves as the chromium content decreases.

Grades having a matrix which is not itself magnetisable become increasingly ferromagnetic with chromium contents over 2,5 %, because any precipitated chromium-rich carbides are ferromagnetic.

In grade EN-GJSA-XNiMn23-4 (5.3501), chromium is an unwanted alloying element and should not exceed 0,2 %, otherwise the impact values given in Tables 3 and E.3 will not be attainable. Lower carbon contents will increase the strength, the hardness and the toughness. Castings in this grade with higher carbon content can be cast more easily. Normally, therefore, the aim should be to approach the upper limit of carbon content.

For grade EN-GJSA-XNiCrNb20-2 (5.3502), it is necessary to maintain the narrow limits for the alloying elements because otherwise weldability can be impaired; in particular, low magnesium and phosphorus contents are necessary.

Molybdenum is not a specified element, but in spheroidal graphite austenitic cast iron grades an addition of up to 1 % Mo will improve the high temperature properties, with only a slight reduction in ductility. Resistance to rupture and creep is beneficially affected by addition of molybdenum.

Non-magnetic alloys can become ferromagnetic again with nickel contents above 25 %.

Annex E
(informative)

Additional information on mechanical and physical properties

Tables E.1 and E.2 give typical mechanical and physical properties of the engineering and special purpose grades.

Table E.3 gives typical values for low temperature mechanical properties of EN-GJSA-XNiMn23-4 (5.3501).

Table E.4 gives typical values for elevated temperature mechanical properties of spheroidal graphite austenitic cast iron grades.

Table E.1 — Typical mechanical properties at (23 ± 5) °C

Grade	Material designation		0,2 % proof strength $R_{p0,2}$	Tensile strength R_m	Elongation A	Compression strength	Charpy V impact energy value	Modulus of elasticity E	Brinell hardness
	Symbol	Number	MPa	MPa	%	MPa	J	GPa	HBW
Engineering	EN-GJLA-XNiCuCr15-6-2	5.1500	—	170 to 210	2	700 to 840	—	85 to 105	120 to 215
	EN-GJSA-XNiCr20-2	5.3500	210 to 250	370 to 480	7 to 20	—	11 to 24	112 to 130	140 to 255
	EN-GJSA-XNiMn23-4	5.3501	210 to 240	440 to 480	25 to 45	—	20 to 30	120 to 140	150 to 180
	EN-GJSA-XNiCrNb20-2	5.3502	210 to 250	370 to 480	8 to 20	—	11 to 24	112 to 130	140 to 200
	EN-GJSA-XNi22	5.3503	170 to 250	370 to 450	20 to 40	—	17 to 29	85 to 112	130 to 170
	EN-GJSA-XNi35	5.3504	210 to 240	370 to 420	20 to 40	—	10 to 18	112 to 140	130 to 180
	EN-GJSA-XNiSiCr35-5-2	5.3505	200 to 270	370 to 500	10 to 20	—	7 to 12	130 to 150	130 to 170
Special purpose	EN-GJLA-XNiMn13-7	5.1501	—	140 to 220	—	630 to 840	—	70 to 90	120 to 150
	EN-GJSA-XNiMn13-7	5.3506	210 to 260	390 to 470	15 to 18	—	15 to 25	140 to 150	120 to 150
	EN-GJSA-XNiCr30-3	5.3507	210 to 260	370 to 480	7 to 18	—	5	92 to 105	140 to 200
	EN-GJSA-XNiSiCr30-5-5	5.3508	240 to 310	390 to 500	1 to 4	—	1 to 3	90	170 to 250
	EN-GJSA-XNiCr35-3	5.3509	210 to 290	370 to 450	7 to 10	—	4	112 to 123	140 to 190

Table E.2 — Typical physical properties

Grade	Material designation		Mass density ρ	Linear expansion coefficient (between 20 °C and 200 °C) α	Thermal conductivity λ	Specific heat capacity c	Resistivity	Permeability (where H = 79,58 A/cm)
	Symbol	Number	kg/dm^3	µm/(m · K)	W/(m · K)	J/(g · K)	µΩ · m	
Engineering	EN-GJLA-XNiCuCr15-6-2	5.1500	7,3	18,7	39,00	46 to 50	1,6	1,03
	EN-GJSA-XNiCr20-2	5.3500	7,4 to 7,45	18,7	12,60	46 to 50	1,0	1,05
	EN-GJSA-XNiMn23-4	5.3501	7,45	14,7	12,60	46 to 50	—	1,02
	EN-GJSA-XNiCrNb20-2	5.3502	7,40	18,7	12,60	46 to 50	1,0	1,04
	EN-GJSA-XNi22	5.3503	7,40	18,40	12,60	46 to 50	1,0	1,02
	EN-GJSA-XNi35	5.3504	7,60	5,0	12,60	46 to 50	—	—
	EN-GJSA-XNiSiCr35-5-2	5.3505	7,45	15,10	12,60	46 to 50	—	—
Special purpose	EN-GJLA-XNiMn13-7	5.1501	7,40	17,70	39,00	46 to 50	1,2	1,02
	EN-GJSA-XNiMn13-7	5.3506	7,30	18,20	12,60	46 to 50	1,0	1,02
	EN-GJSA-XNiCr30-3	5.3507	7,45	12,60	12,60	46 to 50	—	—
	EN-GJSA-XNiSiCr30-5-5	5.3508	7,45	14,40	12,60	46 to 50	—	1,10
	EN-GJSA-XNiCr35-3	5.3509	7,70	5,0	12,60	46 to 50	—	—

Table E.3 — Typical values for low temperature mechanical properties of EN-GJSA-XNiMn23-4 (5.3501)

Temperature °C	0,2 % proof strength $R_{p0,2}$ MPa	Tensile strength R_m MPa	Elongation A %	Reduction in area after fracture %	Charpy V impact energy value J
+ 20	220	450	35	32	29
0	240	450	35	32	31
– 50	260	460	38	35	32
– 100	300	490	40	37	34
– 150	350	530	38	35	33
– 183	430	580	33	27	29
– 196	450	620	27	25	27

Table E.4 — Typical values for mechanical properties of spheroidal graphite austenitic cast iron grades at elevated temperatures

Property	Unit	Temperature °C	Engineering		Special purpose		
			EN-GJSA-XNiCr20-2 (5.3500) EN-GJSA-XNiCrNb20-2 (5.3502)	EN-GJSA-XNi22 (5.3503)	EN-GJSA-XNiCr30-3 (5.3507)	EN-GJSA-XNiSiCr30-5-5 (5.3508)	EN-GJSA-XNiCr35-3 (5.3509)
0,2 % proof strength $R_{p0,2}$	MPa	20	246	240	276	312	288
		430	197	184	—	—	—
		540	197	165	199	291	181
		650	176	170	193	239	170
		760	119	117	107	130	131
Tensile strength R_m	MPa	20	417	437	410	450	427
		430	380	368	—	—	—
		540	335	295	337	426	332
		650	250	197	293	337	286
		760	155	121	186	153	175
Elongation (accelerated test)	%	20	10,5	35	7,5	3,5	7
		430	12	23	—	—	—
		540	10,5	19	7,5	4	9
		650	10,5	10	7	11	6,5
		760	15	13	18	30	24,5
Creep strength (1 000 h)	MPa	540	197	148	—	—	—
		595	(127)	(95)	165	120	176
		650	84	63	(105)	(67)	(105)
		705	(60)	(42)	68	44	70
		760	(39)	(28)	(42)	(21)	(39)
Stress required to reach a minimum creep rate of 1 % per 1 000 h	MPa	540	162	91	—	—	(190)
		595	(92)	(63)	—	—	(112)
		650	56	40	—	—	(67)
		705	(34)	(24)	—	—	56
Stress required to reach a minimum creep rate of 1 % per 10 000 h	MPa	540	63	—	—	—	—
		595	(39)	—	—	—	70
		650	24	—	—	—	—
		705	(15)	—	—	—	39
Creep elongation (1 000 h)	%	540	6	14	—	—	—
		595	—	—	7	10,5	6,5
		650	13	13	—	—	—
		705	—	—	12,5	25	13,5

NOTE The values in brackets are interpolated or extrapolated.

Annex F
(normative)

Sectioning procedure for cast samples

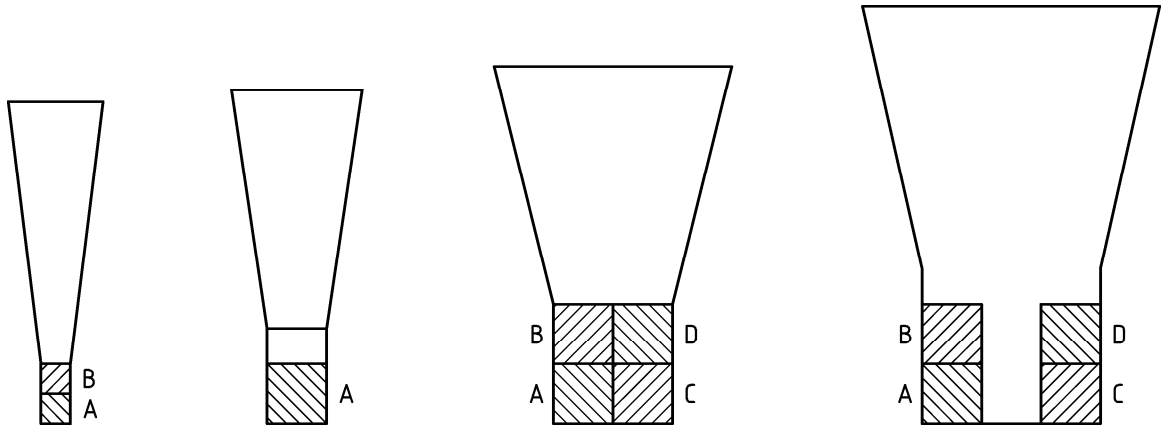


Figure F.1 — Sectioning procedure for Y-shaped samples (see Figure 2)

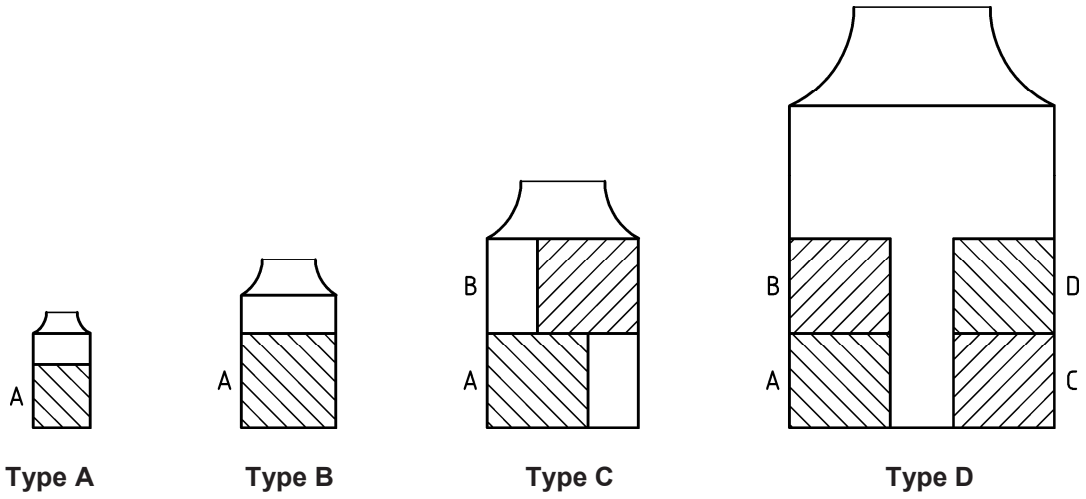


Figure F.2 — Sectioning procedure for cast-on samples (see Figure 4)

Annex G
(informative)

Sample preparation for the determination of physical properties

In determining the physical properties of austenitic cast irons, it is important to bear in mind that the casting rim zone will not normally exhibit the same properties as the internal zone of the casting. This is particularly the case for electrical and magnetic properties.

It is therefore advisable to:

— prepare samples which are sufficiently large to avoid casting rim zone effects;

— remove the casting rim zone with care;

— avoid subjecting the material to mechanical stresses so severe that it exhibits plastic deformation on the surface.

If plastic deformation occurs the new rim zone could once again exhibit properties differing from the material in the sample.

It is advisable to produce a test piece of about 10 mm in diameter and 100 mm in length by careful machining (low cutting depth and low cutting speed) from a sample cut from a casting. This procedure avoids martensite formation which could seriously alter the test results. The test piece should then be carefully pickled to remove any traces of abraded ferromagnetic tool particles adhering to its surface.

Annex H
(informative)

Significant technical changes between this European Standard and the previous edition

Table H.1— Significant technical changes between this European Standard and the previous edition

Clause/paragraph/table/figure	Change
3	Definitions added for: cast sample, separately cast sample, side-by-side cast sample, cast-on sample and relevant wall thickness
Tables 1, 2, 3 and 4	Designation by numbers has been changed
Annex B	Informative Annex B added for the comparison of austenitic cast iron material designations according to EN 1560 and ISO/TR 15931
NOTE The technical changes referred include the significant technical changes from the EN revised but is not an exhaustive list of all modifications from the previous version.	

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This European Standard has been prepared under a Mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

For this harmonized supporting standard for materials, presumption of conformity to the Essential Requirements of the Directive is limited to technical data of the material in the standard and does not presume adequacy of the material to specific equipment. Consequently, the technical data stated in the material standard should be assessed against the design requirements of the specific equipment to verify that the Essential Requirements of the Pressure Equipment Directive (PED) are satisfied.

Table ZA.1 — Correspondence between this European Standard and Directive 97/23/EC

Clause(s)/ subclause(s) of this EN	Subject	Qualifying remarks/Notes
Table 3	Material properties	Annex I, 4.1 a) of the Directive
11	Conformity of material and manufacturer's certified documentation	Annex I, 4.3 of the Directive

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

[1] EN 1559-1, *Founding — Technical conditions of delivery — Part 1: General*

[2] EN 1559-3, *Founding — Technical conditions of delivery — Part 3: Additional requirements for iron castings*

[3] EN 1560, *Founding — Designation system for cast iron — Material symbols and material numbers*

[4] EN 10027-2, *Designation systems for steels — Part 2: Numerical system*

[5] ISO 2892, *Austenitic cast irons — Classification*

[6] ISO/TR 15931, *Designation system for cast irons and pig irons*

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